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Attorney Docket: 25582A

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: BABAYOFF, et al.
Serial No.: 10/692,678
Filing Date: October 27, 2003

Group Art Unit: 2877
Examiner: PUNNOOSE, R.M.
Notice of Allowance: 4/8/2005

Title: **IMAGING A THREE-DIMENSIONAL STRUCTURE BY CONFOCAL FOCUSSING AN ARRAY OF LIGHT BEAMS**

TRANSMITTAL LETTER

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Submitted herewith for filing in the U.S. Patent and Trademark Office is the following:

(1) Request for Priority under 35 U.S.C. §119;
(2) Certified Priority Document: 125659.

Respectfully submitted,
NATH & ASSOCIATES PLLC

Date: July 7, 2005

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REQUEST FOR PRIORITY UNDER 35 U.S.C. §119

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In the matter of the above-captioned design application, notice is hereby given that the Applicant claims as priority date(s) August 5, 1998 as the filing date(s) of the corresponding application filed in ISRAEL, bearing Application Number(s) 125659.

A Certified Copy of the corresponding application number is submitted herewith.

Respectfully submitted,
NATH & ASSOCIATES PLLC

Date: July 7, 2005

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שהופקדו לכתחילה עם
הבקשה לפטנט לפי הפרטים
הרשומים בעמוד הראשון של
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This 28-06-2005 היום

רשם הפטנטים

Commissioner of Patents

ד"ר מאיר נוס

רשם הפטנטים, המדגמים וסימני המסחר

נתאשר
Certified

חוק הפטנטים, תשכ"ז – 1967
PATENTS LAW, 5727-1967

בקשה לפטנט
Application For Patent

לשימוש הלשכה For Office Use	
מספר: Number	125659
תאריך: Date	05-08-1998
הוקדם/נדחה: Ante/Post-dated	

אני, (שם המבקש, מענו ולגבי גוף מאוגדת מקום התאגדותו)
I, (Name and address of applicant, and in case of body corporate-place of incorporation)

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The inventor: Noam BABAYOFF **הממציא: נועם בביוף**

בעל אמצאה מכח הדין Right of Law **ששמה הוא**
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(בעברית) (Hebrew)
שיטה ומכשיר להדמייה תלת-מימדית של מבנה

(באנגלית) (English)
Method and apparatus for imaging three-dimensional structure

Hereby apply for a patent to be granted to me in respect thereof. **מבקש בזאת כי ינתן לי עליה פטנט**

* בקשת חלוקה Application of Division	* בקשת פטנט מוסף Appl. for Patent of Addition	דרישת דין קדימה* Priority Claim		
מבקשת פטנט from application	* לבקשה/לפטנט to Patent/Appl.	מספר/סימן Number/Mark	תאריך Date	מדינת האיגוד Convention Country
No. ____ מס'	No. ____ מס'			
Dated ____ מיום	dated ____ מיום			
P.O.A.: General * יפוי כח: כללי Filed in case 114691 הוגש בענין				
המען למסירת מסמכים בישראל Address for Service in Israel REINHOLD COHN AND PARTNERS Patent Attorneys P.O.B. 4060, Tel-Aviv **C. 112443/7**				
חתימת המבקש Signature of Applicant For the Applicants, REINHOLD COHN AND PARTNERS By : —		היום 4 This בחודש August of שנת 1998 of the year		
				לשימוש הלשכה For Office Use

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This form, impressed with the Seal of the Patent Office and indicating the number and date of filing, certifies the filing of the application the particulars of which are set out above.

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שיטה ומכשיר להדמייה תלת-מימדית של מבנה

Method and apparatus for imaging three-dimensional structure

Cadent Ltd. | קדנט בע"מ

The inventor: Noam BABAYOFF | **הממציא: נועם בביוף**

C.112443/7

METHOD AND APPARATUS FOR IMAGING THREE-DIMENSIONAL STRUCTURE

FIELD OF THE INVENTION

This invention in the field of imaging techniques and relates to a method and an apparatus for imaging three-dimensional structures, particularly useful for direct surveying of teeth.

BACKGROUND OF THE INVENTION

A great variety of methods and systems have been developed for direct optical measurement of teeth and the subsequent automatic manufacture of dentures. The term *"direct optical measurement"* signifies surveying of teeth in the oral cavity of a patient. This facilitates the obtainment of digital constructional data necessary for the computer-assisted design (CAD) or computer-assisted manufacture (CAM) of tooth replacements without having to make any impressions of the teeth. Such systems typically includes an optical probe coupled to an optical pick-up or receiver such as charge coupled device (CCD) and a processor implementing a suitable image processing technique to design and fabricate virtually the desired product.

One conventional technique of the kind specified is based on a laser-triangulation method for measurement of the distance between the surface of the tooth and the optical distance probe, which is inserted into the

oral cavity of the patient. The main drawback of this technique consists of the following. It is assumed that the surface of the tooth reflects optimally, e.g. Lambert's reflection. Unfortunately, this is not the case in practice and often the data that is obtained is not accurate.

Another techniques, which are embodied in CEREC-1 and CEREC-2 systems commercially available from Siemens GmbH, utilize the light-section method and phase-shift method, respectively. Both systems employ a specially designed hand-held probe to measure the three-dimensional coordinates of a prepared tooth. However, the methods require a specific coating (i.e. measurement powder and white-pigments suspension, respectively) to be deposited to the tooth. The thickness of the coating layer should meet specific, difficult to control requirements, which leads to inaccuracies in the measurement data.

By yet another technique, mapping of teeth surface is based on physical scanning of the surface by a probe and by determining the probe's position, e.g. by optical or other remote sensing means, the surface may be imaged.

U.S. Patent No. 5,372,502 discloses an optical probe for three-dimensional surveying. The operation of the probe is based on the following. Various patterns are projected onto the tooth or teeth to be measured and corresponding plurality of distorted patterns are captured by the probe. Each interaction provides refinement of the topography.

SUMMARY OF THE INVENTION

The present invention is directed to a method and apparatus for imaging three-dimensional structures. A preferred, non-limiting embodiment, is concerned with the imaging of a three-dimensional topology of a teeth segment, particularly such where one or more teeth are missing. This may allow the generation of data for subsequent use in design and manufacture, of,

for example prosthesis of one or more teeth for incorporation into said teeth segment. Particular examples are the manufacture of crowns or bridges.

The present invention provides, by a first of its aspects, a method for determining surface topology of a portion of a three-dimensional structure, comprising

(a) providing an array of incident light beams propagating towards the structure and directing them through a focusing optics defining a focal plane, the beams forming a plurality of illuminated spots on the structure;

(b) detecting intensity of returned light beams propagating from each of these spots along an optical path opposite to that of the incident light;

(c) repeating steps (a) and (b) a plurality of times, each time changing position of the focal plane relative to the structure; and

(d) for each of the illuminated spots, determining focal distance yielding a maximum measured intensity of a respective returned light beam, and generating data representative of the topology of the illuminated portion.

By a further of its aspects, the present invention provides an apparatus for determining surface topology of a portion of a three-dimensional structure, comprising:

- an illumination unit for providing an array of incident light beams transmitted towards the structure;
- light directing optics including a light focusing optics defining a focal plane;
- a detector having an array of sensing elements for measuring intensity of each of a plurality of returned light beams, each one propagating through an optical path opposite to that of one of the incident light beams;

- a translation mechanism for displacing said focal plane relative to the structure along an axis defined by the propagation of the incident light beams;
- a processor coupled to said detector for generating data representative of the topology of the illuminated portion.

The determination of the distance yielding maximum intensity in fact amounts to determination of the in-focus distance. The determination of the maximum intensity may be by measuring the intensity *per se*, or typically is performed by measuring the displacement derivative of the intensity curve and determining the relative displacement of maximum derivative. The term *"distance yielding maximum intensity"* will be used to denote the in-focus distance regardless of the manner in which it is determined.

The focal distance yielding maximum intensity for each eliminated spot will be different for different spots. The position of each spot in an **X-Y** frame of reference is known and by knowing the relative positions of the focal plane needed in order to obtain maximum intensity, namely to have the spot in focus, the **Z** or depth coordinate can be associated with each spot and thus by knowing the **X-Y-Z** coordinates of each spot surface topology can be generated.

In order to be able to scan the **Z** coordinate of each eliminated spot on the surface, it is necessary to be able, by one embodiment, to change the focal plane such so as to scan the entire range of depth or **Z** component possible for the scanned surface.

The method and apparatus of the invention are suitable for determining a surface topology of a wide variety of three-dimensional structures. A preferred implementation of method and apparatus of the invention are in determining surface topology of a teeth section.

In accordance with one embodiment of the invention, the method and apparatus are used to construct an object to be fitted within said structure. In

accordance with the above preferred embodiment, such an object is at least one tooth or a portion of a tooth missing in the teeth section. Specific examples include a crown to be fitted on a tooth stump or a bridge to be fitted within teeth.

By one embodiment of the invention, the plurality of incident light beams are produced by splitting a parent beam. Alternatively, each incident light beam or a group of incident light beams may be emitted by a different light emitter. In accordance with a preferred embodiment, light emitted from a light emitter passes through a matrix with an array of apertures thus obtaining an array of light beams.

In accordance with one embodiment, the parent light beam is light emitted from a single light emitter. In accordance with another embodiment, the parent light beam is composed of different light components, generated by different light emitters, the different light components differing from one another by at least one detectable parameter. Such a detectable parameter may, for example be wavelength, phase, different duration or pulse pattern, etc. Typically, each of said light components has its focus in a plane differently distanced from the structure than other light components. In such a case, when the focal plane of the optics is changed, simultaneously the different ranges of depth (or **Z** component) will be scanned. Thus, in such a case, for each illuminated spot there will be at least one light component which will yield a maximum intensity, and the focal distance associated with this light component will then define the **Z** component of the specific spot.

In accordance with an embodiment of the invention the incident light beams are polarized. In accordance with this embodiment, typically the apparatus comprises a polarization filter for filtering out, from the returned light beams, light components having the polarization of the incident light, whereby light which is detected is such having an opposite polarization to that of the incident light.

The data representative of said topology may be used for virtual reconstruction of said surface topology, namely for reconstruction within the computer environment. The reconstructed topology may be represented on a screen, may be printed, etc., as generally known *per se*. Furthermore, the data representative of said topology may also be used for visual or physical construction of an object to be fitted within said structure. In the case of the preferred embodiment noted above, where said structure is a teeth section with at least one missing tooth or tooth portion, said object is a prosthesis of one or more tooth, e.g. a crown or a bridge.

By determining surface topologies from two or more different angular locations relative to the structure, and then combining such surface topologies in a manner known *per se*, a complete three-dimensional representation of the entire structure may be obtained. Data representative of such a representation may, for example, be used for virtual or physical reconstruction of the structure, may be transmitted to another apparatus or system for such reconstruction, e.g. to a CAD/CAM apparatus. Typically, but not exclusively, the apparatus of the invention comprises a communication port for connection to a communication network which may be a computer network, a telephone network, a wireless communication network, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, a preferred embodiment will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1 is a schematic illustration by way of a block diagram of an apparatus in accordance with an embodiment of the invention;

Fig. 2 is a schematic illustration of a probe useful in the apparatus of Fig. 1; and

Fig. 3 is a schematic illustration of an embodiment where the parent light beam, and thus each of the incident light beams, is composed of several light components, each originating from a different light emitter.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Reference is first being made to Fig. 1 illustrating, by way of a block diagram an apparatus generally designated 20, consisting of an optical device 22 coupled to a processor 24. The embodiment illustrated in Fig. 1 is particularly useful for determining the three-dimensional structure of a teeth segment 26, particularly a teeth segment where at least one tooth or portion of tooth is missing for the purpose of generating data of such a segment for subsequent use in design or manufacture of a prosthesis of the missing at least one tooth or portion, e.g. a crown or a bridge. It should however be noted, that the invention is not limited to this embodiment, and applies, *mutatis mutandis*, also to a variety of other applications of imaging of three-dimensional structure of objects, e.g. for the recordal or archeological objects, for imaging of a three-dimensional structure of any of a variety of biological tissues, etc.

Optical device **22** comprises, in this specific embodiment, a semiconductor laser unit **28** emitting a laser light, as represented by arrow **30**. The light passes through a polarizer **32** which gives rise to a certain polarization of the light passing through polarizer **32**. The light then enters into an optic expander **34** which improves the numerical aperture of the light beam **30**. The light beam **30** then passes through a module **38**, which may, for example, be a grating or a micro lens array which splits the parent beam **30** into a plurality of incident light beams **36**, represented here, for ease of illustration, by a single line. The operation principles of module **38** are known *per se* and the art and these principles will thus not be elaborated herein.

The light unit **22** further comprises a partially transparent mirror **40** having a small central aperture. It allows transfer of light from the laser

source through the downstream optics, but reflects light travelling in the opposite direction. It should be noted that in principle, rather than a partially transparent mirror other optical components with a similar function may also be used, e.g. a beam splitter. The aperture in the mirror **40** improves the measurement accuracy of the apparatus. As a result of this mirror structure the light beams will yield a light annulus on the illuminated area of the imaged object as long as the area is not in focus; and the annulus will turn into a completely illuminated spot once in focus. This will ensure that a difference between the measured intensity when out-of- and in-focus will be larger. Another advantage of a mirror of this kind, as opposed to a beam splitter, is that in the case of the mirror internal reflections which occur in a beam splitter are avoided, and hence the signal-to-noise ratio improves.

The unit further comprises a confocal optics **42**, typically operating in a telecentric mode, a relay optics **44**, and an endoscopic probe **46**. Elements **42, 44** and **46** are generally as known *per se*. It should however be noted that telecentric confocal optics avoids distance-introduced magnification changes and maintains the same magnification of the image over a wide range of distances in the **Z** direction (the **Z** direction being the distance from the object). The relay optics enables to maintain a certain numerical aperture of the beam's propagation.

The endoscopic probe typically comprises a rigid, light-transmitting medium, which may be a hollow object defining within it a light transmission path or an object made of a light transmitting material, e.g. a glass body or tube. At its end, the endoscopic probe typically comprises a mirror of the kind ensuring a total internal reflection and which directs the incident light beams towards the teeth segment **26**. The endoscope **46** thus emits a plurality of incident light beams **48** impinging on to the surface of the teeth section.

Incident light beams **48** form an array of light beams arranged in an **X-Y** plane, in the Cartasian frame **50**. As the surface on which the incident light beams hits is an uneven surface, the illuminated spots **52** are displaced from one another along the **Z** axis, at different (X_i,Y_i) locations. Thus, while a spot at one location may be in focus of the optical element **42**, spots at other locations may be out-of-focus. Therefore, the light intensity of the returned light beams (see below) of the focused spots will be at its peak, while the light intensity at other spots will be off peak. Thus, for each illuminated spot, a plurality of measurements of light intensity are made at different positions along the Z-axis and for each of such (X_i,Y_i) location, typically the derivative of the intensity over distance (Z) will be made, the Z_i yielding maximum derivative will be the in-focus distance. As pointed out above, where, as a result of use of the punctured mirror **40**, the incident light forms a light disk on the surface when out of focus and a complete light spot only when in focus, the distance derivative will be larger when approaching in-focus position thus increasing accuracy of the measurement.

The light scattered from each of the light spots defines a beam travelling initially in the **Z** axis along the opposite direction of the optical path traveled by the incident light beams. Each returned light beam **54** corresponds to one of the incident light beams **36**. Given the unsymmetrical properties of mirror **40**, the returned light beams are reflected in the direction of the detection optics generally designated **60**. The detection optics comprises a polarizer **62** that has a plane of preferred polarization oriented normal to the plane polarization of polarizer **32**. The returned polarized light beam **54** pass through an imaging optic **64**, typically a lens or a plurality of lenses, and then through a matrix **66** comprising an array of pinholes. CCD camera has a matrix or sensing elements each representing a pixel of the image and each one corresponding to one pinhole in the array **66**.

The CCD camera is connected to the image-capturing module **80** of processor unit **24**. Thus, each light intensity measured in each of the sensing elements of the CCD camera, is then grabbed and analyzed, in a manner to be described below, by processor **24**.

Unit **22** further comprises a control module **70** connected to a controlling operation of both semi-conducting laser **28** and a motor **72**. Motor **72** is linked to telecentric confocal optics **42** for changing the relative location of the focal plane of the optics **42** along the Z-axis. In a single sequence of operation, control unit **70** induces motor **72** to displace the optical element **42** to change the focal plane location and then, after receipt of a feedback that the location has changed, control module **70** will induce laser **28** to generate a light pulse. At the same time it will synchronize image-capturing module **80** to grab data representative of the light intensity from each of the sensing elements. Then in subsequent sequences the focal plane will change in the same manner and the data capturing will continue over a wide focal range of optics **44, 44**.

Image capturing module **80** is connected to a CPU **82** which then determines the relative intensity in each pixel over the entire range of focal planes of optics **42, 44**. As explained above, once a certain light spot is in focus, the measured intensity will be maximal. Thus, by determining the Z_i corresponding to the maximal light intensity or by determining the maximum displacement derivative of the light intensity, for each pixel, the relative position of each light spot along the **Z** axis can be determined. Thus, data representative of the three-dimensional pattern of a surface in the teeth segment, can be obtained. This three-dimensional representation may be displayed on a display **84** and manipulated for viewing, e.g. viewing from different angles, zooming-in or out, by the user control module **86** (typically a computer keyboard). In addition, the data representative of the surface topology may be transmitted through an appropriate data port, e.g. a

modem **88**, through any communication network, e.g. telephone line **90**, to a recipient (not shown) e.g. to an off-site CAD/CAM apparatus (not shown).

By capturing, in this manner, an image from two or more angular locations around the structure, e.g. in the case of a teeth segment from the buccal direction, from the lingal direction and optionally from above the teeth, an accurate three-dimensional representation of the teeth segment may be reconstructed. This may allow a virtual reconstruction of the three-dimensional structure in a computerized environment or a physical reconstruction in a CAD/CAM apparatus.

As already pointed out above, a particular and preferred application is imaging of a segment of teeth having at least one missing tooth or a portion of a tooth, and the image can then be used for the design and subsequent manufacture of a crown or any other prosthesis to be fitted into this segment.

Reference is now being made to Fig. 2, which is a schematic illustration of an endoscopic probe in accordance with an embodiment of the invention. The endoscopic probe, generally designated **100**, has a stem **102** defining a light transmission path (e.g., containing a void elongated space, being made of or having an interior made of alight transmitting material. Probe **102** has a trough-like probe end **104** with two lateral probe members **106** and **108** and a top probe member **110**. The optical fibers have light emitting ends in members **106, 108** and **110** whereby the light is emitted in a direction normal to the planes defined by these members towards the interior of the trough-like structure **104**. The probe is placed over a teeth segment **120**, which in the illustrated case consists of two teeth **122** and **124**, and a stamp **126** of a tooth for placement of a crown thereon. Such a probe will allow the simultaneous imaging of the surface topology of the teeth segment from three angles and subsequently the generation of a three-dimensional structure of this segment.

Reference is now being made to Fig. 3. In this figure, the number of components of an apparatus generally designated **150** in accordance with another embodiment are shown. Other components, not shown, may be similar to those of the embodiment shown in Fig. 1. In this apparatus a parent light beam **152** is a combination of light emitted by a number of laser light emitters **154A, 154B** and **154C**. Optic expander unit **156** then expands the single parent beam into an array of incident light beams **158**. Incident light beams pass through unidirectional mirror **160**, then through optic unit **162** towards object **164**.

The different light components composing parent beam **152** may for example be different wavelengths, a different one transmitted from each of laser emitters **154A-C**. Thus, parent light beam **152** and each of incident light beams **158** will be composed of three different light components. The image of the optics, or an optical arrangement associated with each of light emitters may be arranged such that each light component focuses on a different plane, **PA, PB** and **PC**, respectively. Thus in the position shown in Fig. 3, incident light beam **158A** bounces on the surface at spot **170A** which in the specific optical arrangement of optics **162** is in the focal point for light component **A** (emitted by light emitter **154A**). Thus, the returned light beam **172A**, passing through detection optics **174** yield maximum measured intensity of light component **A** measured by two-dimensional array of spectrophotometers **176, e.g. a 3 CHIP CCD camera**. Similarly, different maximal intensity will be reached for spots **170B** and **170C** for light components **B** and **C**, respectively.

Thus, by using different light components each one focused simultaneously at a different plane, the time measurement can be reduced as different focal plane ranges can simultaneously be measured.

CLAIMS:

1. A method for determining surface topology of a portion of a three-dimensional structure, comprising

(a) providing an array of incident light beams propagating towards the structure and directing them through a focusing optics defining a focal plane, the beams forming a plurality of illuminated spots on the structure;

(b) detecting intensity of returned light beams propagating from each of these spots along an optical path opposite to that of the incident light;

(c) repeating steps (a) and (b) a plurality of times, each time changing position of the focal plane relative to the structure; and

(d) for each of the illuminated spots, determining focal distance yielding a maximum measured intensity of a respective returned light beam, and generating data representative of the topology of the illuminated portion.

2. The method according to Claim 1, wherein the plurality of incident light beams are produced by splitting a single parent beam.

3. The method according to Claim 1, wherein step (a) comprises polarizing the incident light beams.

4. The method according to Claim 3, wherein step (b) comprises filtering light having polarization same as the incident light and measuring light of opposite polarization.

5. The method according to any one of Claims 1-4, wherein each of said beams is composed of at least two light components different in at least one parameter.

6. The method according to Claim 5, wherein said at least one parameter is selected from the group consisting of wavelength, phase, light pulse duration and pattern.

7. The method according to Claim 5, comprising. in step (b), determining intensity independently for each of said at least two light components in the return light beams.

8. The method according to Claim 7, wherein each of said at least two light components focuses in a plane differently distanced from the structure.

9. The method according to any one of the preceding Claims, wherein the data representative of said topology is used for virtual reconstruction of said surface topology.

10. The method according to any one of Claims 1-9, wherein the data representative of said topology is used for constructing an object to be fitted within said structure.

11. The method according to any one of Claims 1-9, wherein the data representative of said topology is converted into a form transmissible through a communication medium to recipient.

12. The method according to any one of the preceding claims, wherein said structure is a teeth segment.

13. The method according to Claim 12, wherein said structure is a teeth segment with at least one missing tooth or a portion of a tooth and said object is said at least one missing tooth or the portion of the tooth.

14. A method for reconstruction of topology of a three-dimensional structure comprising:

- **(i)** determining surface topologies from at least two different angular locations relative to the structure, by the method defined in any one of Claims 1-13;
- **(ii)** combining the surface topologies to obtain data representative of said structure.

15. The method according to Claim 14, for reconstruction of topology of a teeth portion, comprising:

- determining surface topologies of at least a buccal surface and a lingual surface of the teeth portion, by the method s defined in Claims 12 or 13;
- combining the surface topologies to obtain data representative of a three-dimensional structure of said teeth portion.

16. The method according to Claim 15, for obtaining data representative of a three-dimensional structure of a teeth portion with at least one missing tooth or a portion of a tooth.

17. The method according to Claim 16, wherein said data is used in a process of designing or manufacturing of a prostheses of said at least one missing tooth or a portion of a tooth.

18. The method according to Claim 17, wherein said prostheses is a crown or a bridge.

19. An apparatus for determining surface topology of a portion of a three-dimensional structure, comprising:

- an illumination unit for providing an array of incident light beams transmitted towards the structure;
- light directing optics including a light focusing optics defining a focal plane;
- a detector having an array of sensing elements for measuring intensity of each of a plurality of returned light beams, each one propagating through an optical path opposite to that of one of the incident light beams;
- a translation mechanism for displacing said focal plane relative to the structure along an axis defined by the propagation of the incident light beams;
- a processor coupled to said detector for generating data representative of the topology of the illuminated portion.

20. The apparatus according to Claim 19, wherein said illumination unit comprises a source emitting a parent light beam and a beam splitter for splitting the parent beam into said array of incident light beams.

21. The apparatus according to Claim 20, wherein said illumination unit comprises a grating or microlens array.

22. The apparatus according to any one of Claims 19-21, wherein said incident light beams are polarized.

23. The apparatus according to Claim 22, comprising a polarization filter for filtering out from the returned light beams light components having the polarization of the incident light beams.

24. The apparatus according to any one of Claim 19-23, wherein the illumination unit comprises at least two light sources and each of said incident beams is composed of light components from the at least two light sources.

25. The apparatus according to Claim 24, wherein the at least two light sources emit each a light component of different wavelength.

26. The apparatus according to Claim 25, wherein said light directing optics defines a different focal plane for each light component and the detector independently detects intensity of each light components.

27. The apparatus according to Claim 24, wherein the at least two light sources are located so as to define optical paths of different lengths for the incident light beams emitted by each of the at least two light sources.

28. The apparatus according to any one of Claims 19-27, wherein said focusing optics operates in a telecentric confocal mode.

29. The apparatus according to any one of Claims 19-28, wherein said light directing optics comprises optical fibers.

30. The apparatus according to any one of Claims 19-29, wherein said sensing elements are an array of charge coupled devices (CCD).

31. The apparatus according to Claim 30, wherein, said detector unit comprises a pinhole array, each pinhole corresponding to one of the CCDs in the CCD array.

32. The apparatus according to any one of Claims 19-31, comprising a unit for generating data for transmission to CAD/CAM device.

33. The apparatus according to Claim 32, comprising a communication port of a communication medium.

34. The apparatus according to any one of Claims 19-33, for determining surface topology of a teeth portion, comprising an optical probe for placing proximal to the teeth.

For the Applicants,
REINHOLD COHN AND PARTNERS
By:

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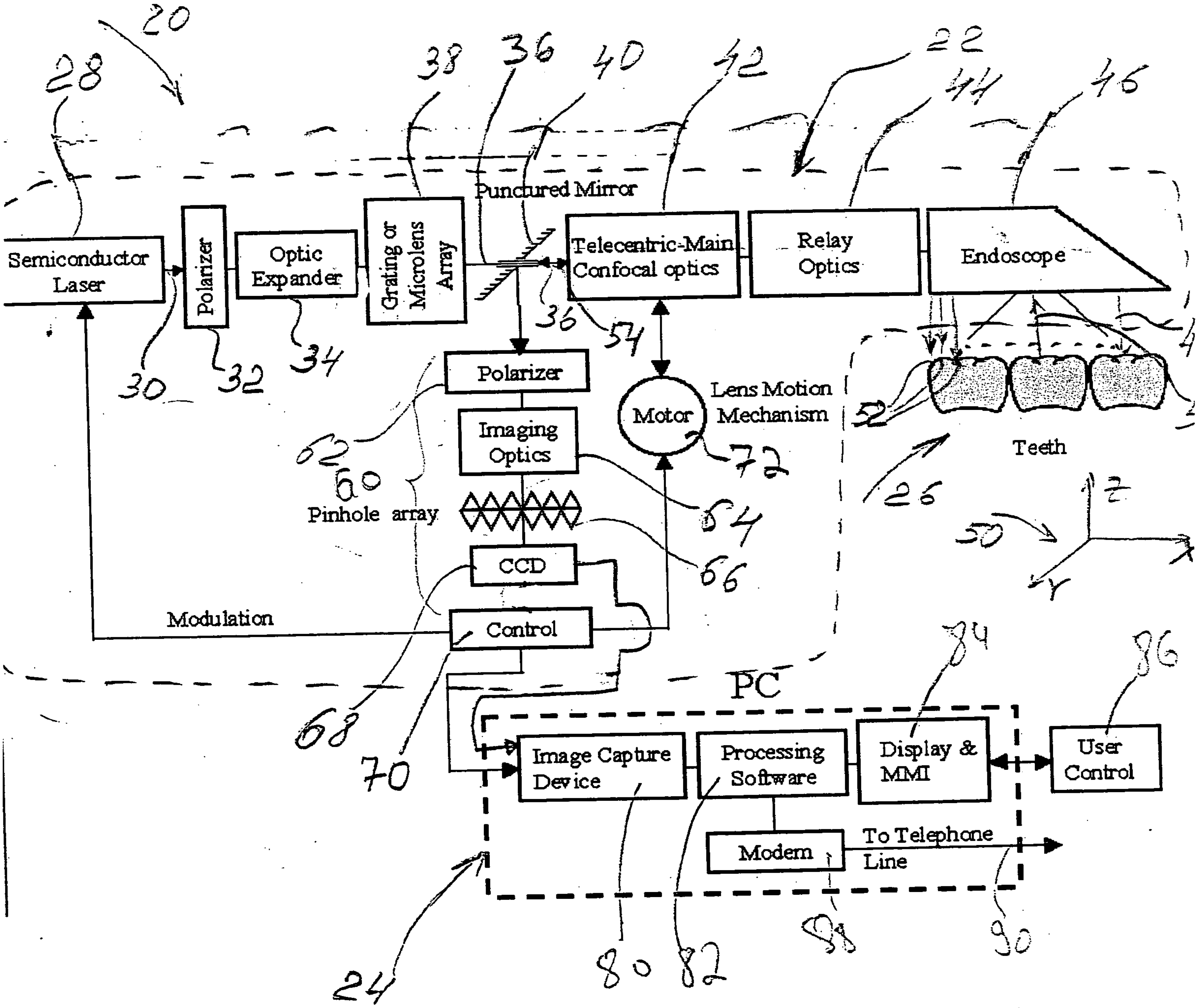

Fig. 1

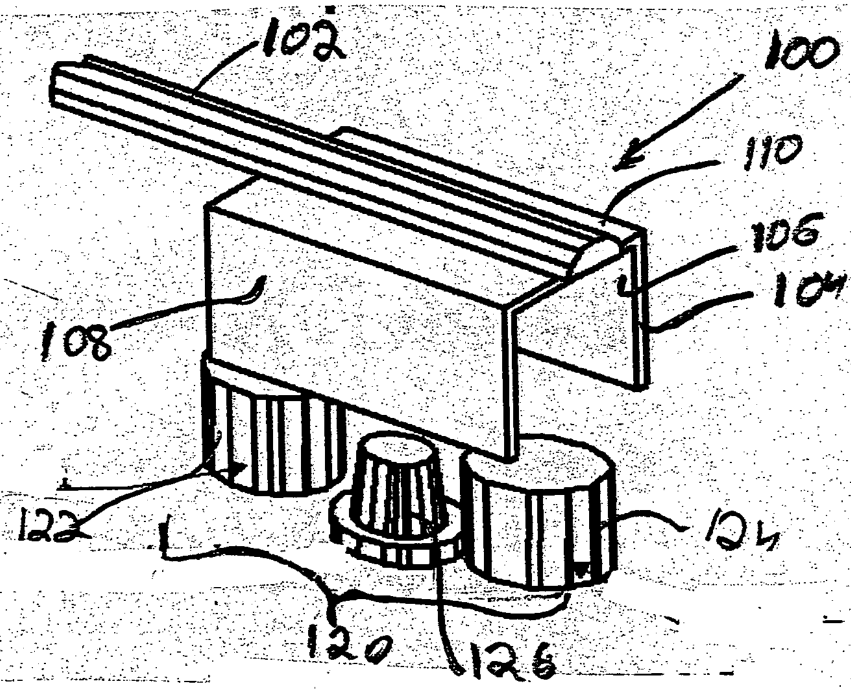

Fig 2

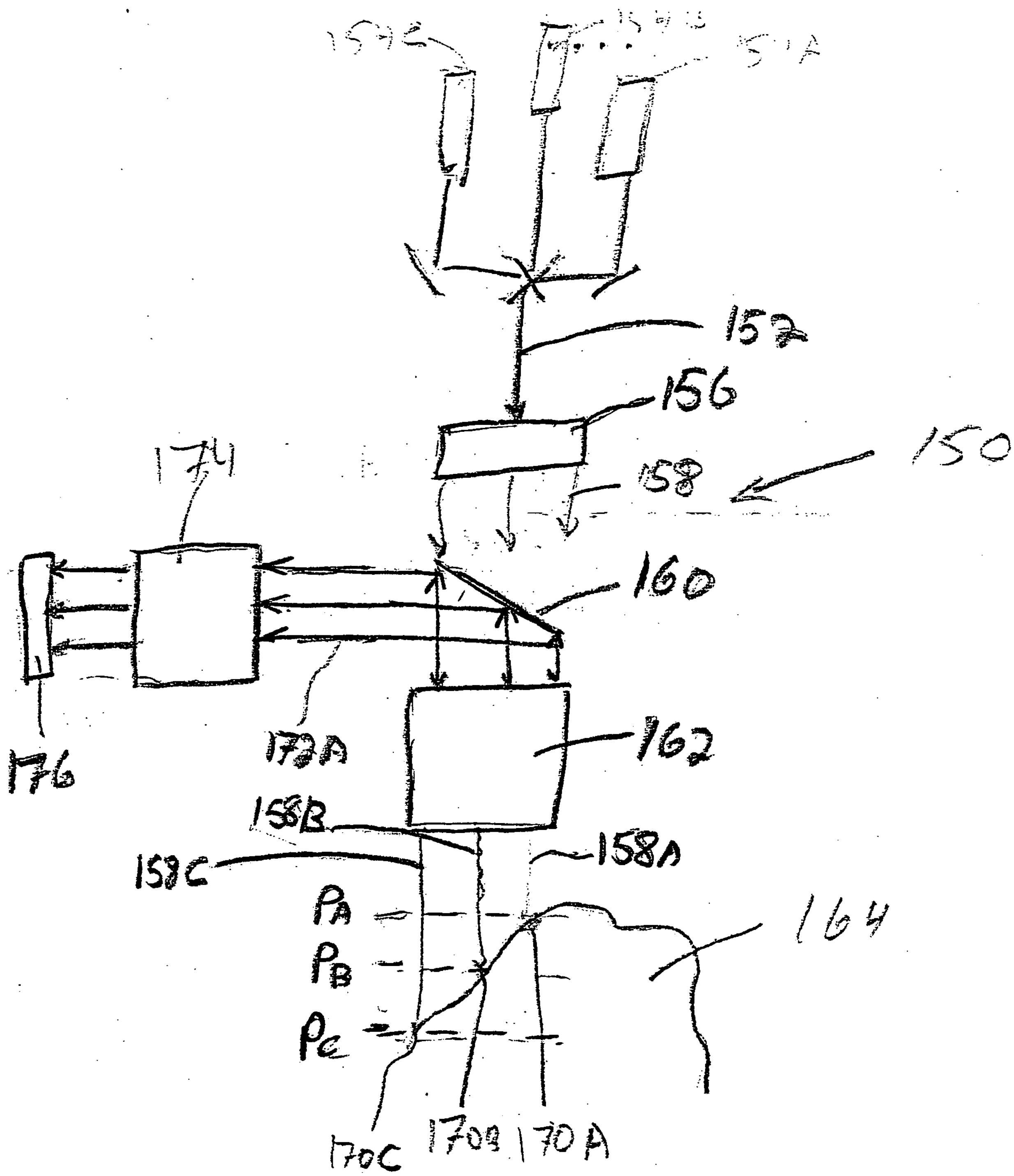

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Fig. 3

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